THE

VETERINARY JOURNAL

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FEBRUARY, 1941

Editorial

STERILITY IN DOMESTIC ANIMALS

In this number of the Veterinary Journal is published an article which summarizes to some extent the present knowledge appertaining to the losses due to sterility, especially in cattle, and its causes, diagnosis, treatment and prevention. Veterinary surgeons and agriculturists are well aware of the heavy losses associated with impaired fertility and sterility. There seems little doubt that artificial methods, apparently necessary from an economic standpoint, may contribute to the high incidence. More and more research work is urgently required to explain the root causes; every encouragement must be given for an adequate supply of trained workers and for funds to enable the tedious work to be carried out. Endocrinology must be given an even more important place in our programmes of study and research. The relationship of nutrition (especially such substances as vitamin E, trace elements, etc.) to infertility in livestock must receive much attention. Extensive research has been carried out concerning some of these aspects of the causation in small laboratory animals, more rarely in farm animals; the experiences gained from such investigations must ultimately be applied to the various types of livestock.

In the meantime, however, we as a profession, have at our command some knowledge and methods, the practice of which is of much value in the control of sterility and in the prevention of infertility—often temporary in character—developing into a state of permanent, incurable sterility. Evidence is accumulating that much of the infertility and sterility in cattle arises from an infection of the genital tract, especially metritis. The infection may be specific, e.g., due to Br. abortus, trichomonads, etc., and its prevention or cure will, in many cases, be followed by satisfactory breeding results. The infection may also be non-specific, arising from many different causes associated with local or general disturbances. Early appropriate treatment is followed in many cases by recovery to such a degree that normal pregnancy can be assured. The application of the various known treatments is the work of the veterinary practitioner; it is the duty of all concerned to ensure that such early treatment is applied. Veterinary practitioners must all acquire the necessary techniques and arrangements must be made whereby early access to breeding herds is assured. By such a practice we may expect an early reduction in the incidence of infertility in cattle with a consequent increase in milk and meat.

It is of the utmost importance at this time that veterinary practitioners give serious attention to the control of sterility in livestock.

IMMUNISATION AGAINST BOVINE TUBERCULOSIS

Since the days of Koch, attempts have been made to immunise animals against tuberculosis. Various agents have been used, e.g., tuberculin, killed cultures of the tubercle bacillus as well as cultures treated in different ways. Within fairly recent times B.C.G. has been the subject of experiments in many countries and a considerable amount of literature has been published. In this country critical experiments have been carried out; the results have been published and indicate that B.C.G. affords some protection against heavy infection of bovine tuberculosis. We still await the results of field trials carried out under natural conditions in the field. More recently two papers have been published which indicate that the injection of cultures of the vole strain of acid-fast organism (isolated by Wells) induces, in guinea-pigs and calves, a fair degree of protection against subsequent infection with bovine tuberculosis. (Abstracts of the papers are published in this number). These findings are of immediate interest and importance. It may be that, in the absence of schemes for the eradication of tuberculosis, immunisation methods may have to be considered. The results to date with the vole strain of acid-fast organism are of sufficient importance and value to merit further investigation.

General Articles

STERILITY AND IMPAIRED FECUNDITY IN FARM ANIMALS

By HENRY P. FOX, D.V.Sc., D.Agr.Sc., M.R.C.V.S.

INTRODUCTION

It is hardly possible to give within the space of a single article a complete and critical account of the economic importance and of the causes and modern methods of diagnosis, treatment and prevention of sterility and impaired fecundity in farm animals. The subject is so vast that a special treatise would be required for this purpose. Only the more salient facts, mostly selected from the contemporary relevant literature, will be reviewed in this rapid survey.

The adult male and female animal is normally fertile, i.e., the sire is capable of begetting and the dam of conceiving and carrying to term the calf, lamb, foal, etc. The term " sterility " signifies a total inability to reproduce. The variations in individual reproductive capacity, ranging between normal fertility and pathological sterility, are due to a multiplicity of ætiological factors and may be conveniently classified under the heading—impaired fecundity.

Considerable progress has been achieved in different fields of comparative and applied biology in the first four decades of the twentieth century. Laws have been discovered governing the nature and mode of inheritance; they provided a solid material foundation for the working hypotheses of earlier workers about heredity and the relative importance of natural selection and environment in the process of evolution.

In no other domain, however, has the advance of our knowledge been more spectacular and more beneficial to the breeder than in the group of studies devoted to the physiology and pathology of reproduction. It is only now that influence exercised upon the reproductive function or dysfunction by the pituitary-thyroid-gonad mechanism comes to be appreciated, and new knowledge thus acquired, after many years of patient groping and animal experimentation, is being applied in practice.

Nutritional research, development of vitamin studies and synthetisation of some of the vitamins has thrown fresh light upon many obscure problems of animal feeding and has now enabled the progressive breeder to keep his livestock on scientifically balanced diets.

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Simultaneously with the discovery of new factors influencing the reproductive health of farm animals, and not altogether unexpectedly, a steady rise in the incidence of sterility and impaired fecundity has taken place. This has undoubtedly been due to the rapid dissemination of the newly acquired knowledge and to the early recognition by the breeder and diagnosis by the veterinary practitioner of abberant sexual phenomena. Animal breeders, both in temperate zones and in tropical and sub-tropical regions, where the farms and ranches are run on intensive, semi-intensive and extensive lines, suffer increasing loss through breeding failures.

I. The Economic Importance of Sterility and Impaired Fecundity of Farm Animals

As aberrations of reproductive health do not come under the schedule of notifiable animal diseases, no accurate statistics of their incidence are at present available in this country.

Individual workers and research institutes had in the past attempted statistically to assess wastage due to failure to reproduce in herds of dairy cattle, in flocks of fine-wool and mutton type of sheep and in horse studs; in the absence of more reliable and correlated information use must necessarily be made of their findings.

Cattle.

Udall and others[37a] examined in the U.S.A. 1,000 consecutive cases of diseases of the genital organs of cows during 1920-4. They found that abortion, retention of the afterbirth, *sterility*, metritis, dystokia and miscellaneous causes accounted each for 30.7, 17.8, *17.4*, 13.9, 12.5 and *7.7* per cent. of the total, respectively.

Hetzel[19a] investigated in Hungary between 1911 and 1926 the relative incidence of sterility due to the various pathological conditions in dairy herds with the population of 5,614 head. He found that 30.8 per cent. of animals suffered from different diseases of the genital organs, and that 16.03 per cent. were affected by sterility, 75.26 per cent. of the cases with ovarian disease and 66.66 per cent. with tubal disease resulted in sterility; the corresponding figures for the uterine and vaginal affections were 48.79 and 19.41 per cent. respectively; of miscellaneous and unknown diseases—69.1 and 100.00 per cent. respectively ended in sterility; the latter accounted for 62.37 per cent. of the total incidence of the genital disease, whereas 53.09 per cent. of those treated for sterility recovered. The true wastage, i.e., the number of cows eliminated from the herds on account of sterility, was equal to 5.5 per cent. of the total cattle population.

Hunter-Smith[35a] investigated conditions in a dairy herd between 1912 and 1932. Over the whole period of twenty years the sex ratio was equal, but only 34 per cent. of all the calves became dairy cows. In round figures ten calves or five heifer calves were required to produce three dairy cows.

The annual average " wastage " due to all causes was at the rate of two animals out of nine. Eighty to ninety per cent. of the discards from the herd have been either " wasters " or " barreners "; all other causes of disposal when taken together were comparatively insignificant; abortion, sterility and tuberculosis—in order of importance—were the chief causes of wastage. The average herd life of a cow was three years and five months.

Sanders,[35] in a report of investigation into the causes of the removal of cows from dairy herds, recorded data collected between 1928-31 from 1,572 herds with 37,816 cows owned by members of milk-recording societies in Bedfordshire, Cambridgeshire, Hertfordshire, Lincolnshire and Norfolk. Relative importance of the various causes of death or disposal, as expressed in percentages of total wastage, may be assessed from Table 1.

TABLE 1.

Cause of death or disposal.	Percentage of total wastage.
Sterility	25.66
Abortion	3.37
Tuberculosis	5.04
Johne's Disease	2.12
" Wasters "	2.81
" Garget "	1.03
Other udder troubles	4.20
" Died "	4.88
Accident	1.23
Miscellaneous	4.01
Total " Disease "	54.35
T.B. Test	2.77
" Low Yielders "	18.38
Old Age	4.32
Trade	20.18
Total	100.00

(After Sanders)

" Sterility was the chief cause of loss and was responsible for just one quarter of the total wastage, or nearly one half of that due to ' disease.' " Although such classifications as " wasters " and " died " are open to criticism and are liable to cause confusion in accurate appraisal of wastage, the data summarised in Table 1 give a fairly representative picture of the causes of wastage in dairy herds. It is significant that disposals due to low milk yield account for 18.38 per cent. of the total wastage, and those because of positive reaction to tuberculin tests and old age account only for 2.77 and 4.32 per cent. respectively. Another point of interest is the comparatively high percentage (20.18) of cows passed into the normal trade channels.

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According to the same author the average herd life of a cow in the population covered by his report was close to 3½ years. He classified methods of disposal of "diseased" cows according to cause of disposal as expressed in percentage distributions of condition at the sale (Table 2).

TABLE 2.

Cause of Disposal	How sold: In Milk	In Calf	Dry Store	Fat	Dead	Per cent. lost to dairy industry	True wastage as % of no. of cows in the herd
Sterility	11.5	—	20.9	67.6	—	88.5	5.09
"Low Yielders" .	27.7	14.6	17.0	40.7	—	57.7	2.39
"Died"	—	—	—	—	100.0	100.0	1.09
Tuberculosis ...	29.7	2.3	22.4	4.3	41.3	68.0	0.77
Old age	19.8	9.2	23.4	36.7	10.9	71.0	0.69
Other udder troubles	28.0	8.0	19.0	43.8	1.2	64.0	0.60
Trade	62.4	25.4	7.6	4.6	—	12.2	0.55
Miscellaneous ...	36.8	8.8	21.5	23.8	9.1	54.4	0.49
Abortion	33.9	3.2	10.8	49.3	2.8	62.9	0.48
"Wasters" ...	26.4	3.5	45.0	5.2	19.9	70.1	0.44
Johne's Disease ...	33.0	4.4	30.2	—	32.4	62.6	0.30
Accident	15.4	2.9	7.7	16.3	57.7	81.7	0.23
T.B. Test ...	60.3	10.6	18.0	11.1	—	29.1	0.18
"Garget" ...	31.0	6.0	29.7	29.7	3.6	63.0	0.14
All causes ...	30.3	9.7	17.0	33.1	9.9	60.0	13.45

(After Sanders)

"This serves to emphasise yet more the great part played by sterility in the depletion of dairy herds"; 88.5 per cent. of cows eliminated from herds on account of sterility are lost to the dairy industry; and it is responsible for over one half of the true wastage due to "disease." A total of 5.09 per cent. of 37,816 cows in 1,572 herds were "wasted" on account of sterility. To assess the magnitude of the estimated annual loss due to this cause let us assume that the above percentage (5.09 per cent.) would hold true in regard to the total dairy cattle population of the United Kingdom which, according to the 1938 census, equalled 6,921,143 head[1]; the estimated loss would then be 352,285 cows, valued at (£20 each)—£7,045,700.

It is significant that whereas considerable sums have been and are being spent on research and measures aiming at reducing the incidence and eradicating the occurrence of tuberculosis, bovine contagious abortion, Johne's disease and mastitis, which accounted altogether for only 1.87 per cent. of total wastage in herds covered by Sander's investigations, no concerted action has yet been taken in tackling the problem of sterility; only small grants were given spasmodically to provide for research into some aspects of its causes and control.

Between 1934 and 1937 Pettit[30] investigated wastage, length of productive life, replacement and depreciation of dairy cows in 249 herds containing 10,033 cows. He found that the annual wastage amounted to 29.3 per cent. of the number of cows at the beginning of the year, and that the average length of productive herd life was 3.4 years. The average cost of depreciation was £3 5s. per cow in the herd per year, equivalent to 1.1d. per gallon of milk produced.

During the same period cows leaving the herd realised an average of £10 10s. 6d. per head; the average market value placed upon heifers when they entered the milking herd was £20 14s., while cows for replacement purposes cost an average of £22 5s. Thus, an average loss of £10 14s.—representing the difference between the sale price of a cow on leaving the herd and the cost of a heifer—has been incurred by the farmer; it rose to £11 15s. when a new cow had to be bought.

If we accept the view that 352,285 head are lost annually to the dairy industry in the U.K, because of sterility, the annual replacement loss shouldered by the farmer would be about £3,500,000, or about 8s. per head of total cattle population in 1938.

Murray[27] investigated conditions in 16 herds in W. Midlands during 1939 and 1940. He calculated that sterility replacement loss per cow per head was 7s. and 8s. for 1939 and 1940 respectively.

As three investigators and the author working in different districts and employing divergent criteria arrived at approximately the same conclusions, it can be safely assumed that the annual replacement loss of dairy cattle is in the neighbourhood of 8s. per head of the total cattle population in the U.K., which on the basis of 1938 census would be equal to the total annual loss of £3,504,279.

Sheep

It is estimated that in this country the depreciation of the ewe constitutes about a third of the cost of lamb production.[3] No investigations to assess the loss due to sterility in sheep flocks—similar to those undertaken in the case of cattle—have been hitherto carried out. Gilruth[15] says that in Australia the ewe of the fine wool strain is less prolific than that of the mutton type. The lambing percentage in the vast majority of flocks, even in favourable seasons, is well under the hundred mark; he did not, however, state what was the normal percentage of lambings in the mutton type of sheep.

The problem of economics of sterility in sheep still awaits its investigators, and particularly so in this country and other parts of the British Empire which carry the majority of world's sheep population.

Horses

Rapid development of motorised road transport and mechanisation of agriculture contributed to the gradual decline of the importance of the horse

as a draught animal with a consequent reduction in numbers; there were in England and Wales 856,713 horses used for agriculture in 1938 as compared with an average of 924,095 for the ten years 1928-37.[1] Nevertheless the horse-breeding industry, and particularly its thoroughbred branch, still has appreciable economic importance. It is reliably computed that £150,000,000 has been invested in it and horse racing and that both provide direct and indirect employment for tens of thousands of people.

Walton[39] states that infertility in mares is very common, and that among heavy horses about 40 per cent. and among thoroughbreds 33 per cent. of mares put to the stallion fail to produce foals.

Reynolds,[31] confirming Walton's estimate, further states that barrenness in mares entails not only a loss due to the failure to breed, but also that due to the wasted stud fees and keeping and travelling sterile mares.

There is no doubt that loss due to sterility and impaired fecundity constitutes a major economic problem facing the horse-breeders in this country to-day, and that there exists an urgent need for more research and investigation in this field.

In none of the branches of the livestock industry have attempts as yet been made to appraise the economic loss due to sterility of the sire. As demonstrated in the case of stallion by Sanders,[34] Day,[7] and Walton and Fair,[38] this must be considerable. Nor has there been made an evaluation of loss due to sterility in captive fur-bearing animals; and that in spite of the fact that fur-farming occupies a place of some importance both in this country and in other parts of the British Empire (Canada). In these fields further research and investigation are urgently needed.

II. A Short Survey of the Causes of Sterility and Impaired Fecundity

The ætiology of sterility must of necessity, on account of recent advances in our knowledge of this complex problem, deal with the multiplicity of factors; they may be physiological, genetical, anatomical, pathological, endocrinal, environmental, nutritional and metabolic. Each of those, in so far as they affect either the sire or the dam, will be dealt with in subsequent notes.

The Sire Factor.

No investigation of the causes of sterility in any herd, flock or stud would be complete without a simultaneous inquiry into the state of reproductive health of the sire used by the farmer. Of late more attention has been paid to the sire factor in the incidence of sterility. Yet in the absence of correlated scientific data on the subject of relative frequency of male and female sterility no assay of the economic importance of the former can be made at present.

True sterility due to purely physiological and anatomical malfunction or

resulting from pre-natal developmental failure is rare in the male farm animals.

Very young or very old sires show, as a rule, a state of physiological sterility due to the dormancy or repression of gonadal activity. Males of certain wild species (stag, hart, moose, elk, hedgehog) experience a definite " rutting " season and remain physiologically sterile during the quiescent stage. Endocrine therapy may accelerate the advent of puberty in immature sires, but claims of rejuvenation by implantations of testicular grafts put forward by Dr. Voronoff were found to be unsubstantiated and requiring further experimental proofs by a committee which Ministry of Agriculture and Fisheries dispatched to Algeria for investigation.[23]

Impotentia coeundi due to congenital central or peripheral lesions of the nervous system or as the result of psychic inhibitions, as is frequently the case with man, is almost unknown in the male farm animals. Neoplasmata of the penis, its hypo- or hyperplasia, phimosis, hypospadias, stricture, induration or fibrosis of the urethra or spermatic cord may occur; they are, however, not the primary, but contributory, factors of sterility, for they preclude normal mating or ejaculation. Cryptorchids, although exhibiting vigorous sexual behaviour, are sterile, for in undescended testes spermatogenesis does not take place. Crew[6a] advanced the view that the scrotum acts as a thermo-regulator and that spermatogenesis does not occur in retained testes because the higher temperature in the abdominal cavity (2 deg. C. higher than in the scrotum) prevents normal development of spermatozoa.

Prolificacy is regarded by many geneticists as a true Mendelian factor in the genetical sense. Individual variations in fertility, for which we here use the term " impaired fecundity " and which can range in the sire from complete necro-or-azoospermia to oligospermia, may become fixed as the result of close in-breeding and thus assume the true Mendelian character on the genetical plane. It is probable that many of the cases of infertility among the thoroughbred sires (stallions, bulls, rams and boars) are due to this cause or to the inherited unbalance of the endocrine apparatus.

Inter-species hybrids, such as mules or hinnies, are invariably sterile. Intersexuality, or what is incorrectly called hermaphroditism, due to developmental failure is comparatively rare, and individuals thus affected are infertile both on account of hypoplasy of the penis and of non-descent of the testes.

In the great majority of cases, however, sterility of the sire is due to external and internal trauma or infection of the external genital organs, gonads and adnexa. Wounds and injuries of the testes, scrotum, penis, sheath or spermatic cord with subsequent infection and atrophy, hydrocele or scrotal hernia, etc., account for most of the recorded cases of male sterility. Tuberculosis, Br. abortus infection and dourine may be directly or indirectly responsible for infertility.

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It has been demonstrated experimentally that extirpation of the anterior pituitary is followed by the cessation of spermatogenesis, and that pituitary and thyroid dysfunction produces similar results. It is, however, unknown at present how far the pituitary-thyroid-gonad mechanism affects the reproductive function of farm animals kept under ordinary conditions and how great is the incidence of sterility and infertility of the sire attributable to pluriglandular malfunction.

Diseases due to gross metabolic disturbances, such as *diabetes mellitus*, anæmia, osteomalacia, adiposity, and some of the conditions associated with chronic sodium, calcium and phosphorus deficiency may result indirectly in male sterility, but there is lack of clinical evidence to support this view.

Prolonged dietary deficiency of vitamin E may result in the male in permanent sterility which cannot be cured by the administration of vitamin E concentrate (wheat germ oil), by implantation of the anterior lobe of the pituitary gland or by treatment with its hormone. No data are at present available in regard to the relative frequency of sterility in the male due to diets deficient in vitamin E.

It has been placed on record that apparently healthy and normal sires may be suffering from temporary or permanent azoospermia, the condition being usually induced in circumstances associated with change of environment upon acclimatisation in a new country. Although instances are known of valuable proven sires becoming temporarily infertile or even sterile upon arrival in tropical and sub-tropical countries, it is doubtful whether environmental or climatic changes alone are responsible for the onset of impaired fecundity or sterility in such cases. It is more likely that faulty or deficient diets, unsuitable for the new environment, bring about metabolic and assimilatory disturbances which, in their turn, produce temporary or permanent pituitary-gonad unbalance. It is just possible that in hot countries the thermoregulating function of the scrotum is impaired in such a way that the temperature within the testes becomes so high as to preclude spermatogenesis.

The dam factor.

Although both the sire and the dam are, on the biological plane, equal in their ability or inability to produce offspring, sterility or impaired fecundity of the dam is economically of greater moment to the livestock owners than that of the sire.

As is the case in the sire, sterility due to physiological and anatomical malfunction or resulting from pre-natal developmental failure is very rare in the dam. Immature and senile female animals are physiologically sterile owing to quiescence or suppression of gonadal function. Normally monœstrous or diœstrous animals (bitch, silver fox, ewe, sow, ferret) are physiologically infertile during the quiescent phase—anœstrum.

Gross teratological and congenital malformations, interfering with the

reproductive capacity of the female animal, are usually detected soon after birth, and individuals so affected are promptly disposed of. Free-martin (the female of the heterosexual bovine twins) is always sterile. True intersexuality—or hermaphroditism—although very rare is always accompanied by functional sterility. Some of the female inter-species hybrids are fertile in a sense that they ovulate and may conceive, but in many instances pregnancies end in fœtal death and atrophy, or in premature expulsion of the fœtus. Male pregnancies, as in the Bison X Domestic Cattle hybrids, very often end fatally owing to dystokia.

Neoplasmata of the external genitalia, vagina and cervix offer mechanical impediments to natural mating and impregnation and must be regarded as contributory but not the primary factors of infertility.

Most of the recorded cases of sterility or impaired fecundity in the dam are due to traumatic or general infection of the external and internal genital organs, gonads and adnexa, or to an acute or chronic disturbance of endocrine equilibrium. Retention of the afterbirth with subsequent bacterial invasion of the uterus, Br. abortus infection, contagious vaginitis, dourine, coital exanthema, etc., are the most frequent causes of temporary or permanent infertility. Chronic debilitating diseases such as tuberculosis (both localised and generalised) or Johne's disease contribute directly or indirectly to the state of infertility. They usually create conditions in which union of gametes becomes impossible, ovulation is repressed, or, where the zygote is formed, implantation does not take place and microscopical abortion follows; in other instances premature expulsion of the fœtus occurs.

According to Albrechtsen[2] disease of the uterus and accessory genitalia is responsible for the great majority of cases of infertility in the dam.

Exact clinical and experimental data are lacking to justify the rather popular view that such gross metabolic disturbances as occur in dams suffering from *diabetes mellitus*, pernicious anæmia, osteomalacia, chronic sodium, calcium and phosphorus deficiency, etc., are alone responsible for the onset of sterility. Nutritional deficiencies probably produce, as infections and lesions of ductless glands do, a state of endocrine unbalance which, *inter alia*, manifests itself in reproductive aberrations or sterility.

In female rats vitamin E deficiency does not inhibit ovulation, œstrum or implantation of the zygote, but the fœtus dies at about the thirteenth day from starvation and asphyxia, due to defective allantois and yolk sac and is resorbed by the twentieth day; this condition can be cured by the administration of vitamin E concentrate (wheat germ oil). No data are at present available regarding the relative incidence among farm animals of female sterility due to vitamin E deficiency.

Recorded cases of sterility in dams exported from temperate zones to tropical and sub-tropical countries are probably due, like well-known phenomenon of amenorrhœa in the human female, to pluriglandular dysfunction.

XUM

Although in the present state of our knowledge it is unknown how disturbances of endocrine equilibrium originate, it would be safe to assume that all cases of sterility in the dam atributable to other than the already enumerated causes are probably due to endocrine unbalance, and to dys-and-malfunction of the pituitary-thyroid-gonad mechanism in particular. This conviction finds support in what Cameron[5] says about the profound influence exercised by the pituitary in the animal organism: "Through some one or other of the several principles it controls (*a*) the thyroid, and thereby the oxidative processes throughout the organism; (*b*) the adrenal cortex, and thereby, in some still undetermined fashion, normal muscle contractility and degree of dilution of the blood and its concentration of electrolytes, especially sodium and chlorine; (*c*) the gradual development of the gonads, and, when these are sufficiently matured to secrete enough of their own specific compounds, through them the development of the secondary sex organs and secondary sex characters; (*d*) carbohydrate metabolism, acting as antagonist to insulin; (*e*) the parathyroids, and, through them, calcium and phosphorus metabolism; (*f*) lactation and maternal behaviour; (*g*) general growth of all tissues; (*h*) fat metabolism; (*j*) the water exchanges of the body; even this list is incomplete."

"Thus it is easy to imagine not only the many effects which marked abnormality of pituitary functions can cause, but also how even slight pituitary changes within normal range of variation can be reflected in so many ways as to result in marked variations in the physiological behaviour of the organism."

As the incidence of wastage due to sterility was found by Sanders[35] and Pettit[30] to be greater in high-yielding dairy herds than in those with average or low yield, we may be allowed to advance the view that bovine sterility may be due, among other factors, to hyper-stimulation and hyper-function of the mammary gland.

Riddle and others[32, 33] have established that the anterior pituitary secretes a lactogenic principle—prolactin. According to Evans[11] and Lyons[21] crude extracts of anterior pituitary produce copious lactation in *virgin and dry goats, in virgin heifers,* and in normal bitches. According to Riddle, prolactin induces lactation in mammals after the mammary glands have been previously stimulated by œstrogenic principles, and is quite possibly the agent which represses ovulation during pregnancy and lactation in mammals.

As sterility and aberrant sexual cycle usually develop in apparently normal cows after the second or third calving, there is probably a direct causal connection between the mammary hyper-function and impaired fecundity controlled in some unknown fashion by the pituitary-gonad mechanism.

Herein lies a fresh field of research for veterinary investigators.

III. Diagnosis

In the sire

In the absence of gross injuries, anatomical malformations, infection, central or peripheral lesions of the nervous system, etc., where the diagnosis

presents no great difficulty, the faulty breeding record of the apparently normal sire is the first indication of aberrant sexual health.

Methods have been developed in modern technique whereby a straightforward assay of fertility in the sire is possible, i.e., the collection of seminal fluid *in toto* or in fractions and its microscopical examination.

Biopsy of testes or epididymis, i.e., obtaining of a piece of testicular parenchyma or of seminal cells from the epididymis of a living animal, can be resorted to in those cases in which the seminal fluid cannot be obtained in any other way. The operation is fairly simple and can be carried out under local anæsthetic alone.

Gunn[17] elaborated a method of electrical stimulation of ejaculation in the ram and obtained complete and fractional ejaculates; its use in large farm animals presents, however, considerable difficulties.

The artificial vagina offers by far the best instrument for collecting the seminal fluid from bulls, rams, stallions and boars if a pure sample is desired, i.e., undiluted by vaginal secretion, as samples recovered from the dam after service are always "impure" in that sense.

The volume, colour, density, consistency of the ejaculate; the density of sperm population, morphological characters of the gametes, their motility and viability outside the animal body; and respiration rate of the spermatozoa in the complete ejaculate are the recognised criteria by which the state of reproductive health of the sire may be appraised.

Donham and his co-workers[8, 9] showed that there exists in cattle a statistical relationship between the motility and viability of spermatozoa on the one hand and the number of pregnancies resulting from heterogeneous sperm samples on the other. (See Tables 3, 4 and 5.)

TABLE 3.

Seminal Examinations in which pregnancy results were not obtained.

Seminal Examinations	Estimated Percentage of Motility of Spermatozoa									
	90—100%		75—90%		50—75%		25—50%		0—25%	
	No.	%	No.	%	No.	%	No.	%	No.	%
101	48	47.52	19	18.81	12	11.88	1	0.99	22	20.79

	No.	%
Normal motility above 90 per cent. ...	48	47.52
Below normal motility	53	52.48
	101	100.00

(After Donham and others)

TABLE 4.

Relation of seminal picture to pregnancy and to breeding efficiency in bulls.

Estimated motility of spermatozoa	Bulls examined	Examinations	Examined service resulted in pregnancy No.	%	Total services of season: Cows bred	Services	Pregnancies	Cows pregnant %	Average services per pregnancy	Services resulting in pregnancies %
Normal Motility (above 90 per cent.)	7	9	5	55.55	181	273	130	75.13	2.10	47.61
Below Normal Motility	10	15	5	33.33	207	348	118	57.0	2.94	33.89
Totals	17	24	10	41.66	388	621	248	69.93	2.50	39.94

(After Donham and others)

TABLE 5.

Relation of seminal picture to pregnancy resulting from that service.

Motility	Resulted in pregnancy No.	%	Pregnancy failures No.	%	Totals
Normal (above 90%)	35	53.03	31	46.97	66
Below 90%	13	24.07	41	75.93	54
Totals	48	40.00	72	60.00	120

Services	Results known	Results unknown	Pregnant No.	%	Barren No.	%	Average services per pregnancy
393	375	18	141	37.60	234	62.40	2.65

(After Donham and others)

Services by bulls with normally motile gametes resulted in twice as many pregnancies as by those with abnormal sperms.

Walton[40] found a definite quantitative inter-relationship between fertility of service, number of spermatozoa in ejaculate and activity of sperms as measured by the respiration rate (see Table 6).

Williams and Savage,[41] using biometrical methods, found that the degree of fertility of bulls was correlated with the morphological characters of the sperm-population, and particularly with the degree of uniformity in the length of the heads of the spermatozoa.

Lane-Roberts and others[20] and Moench[26] confirmed the work of Williams and Savage in the case of man as demonstrated in Figs. 1 and 1a.

TABLE 6.

No. of bulls	Services per conception	Activity/Respiration in cmm./hr./M.	Total No. of spermatozoa. Millions
3	1—1.9	0.058	1,923
6	2—2.9	0.038	1,448
4	3—6.9	0.012	1,245

(After Walton)

Frequency of various head-lengths in a sample of fertile semen.
(After Moench)

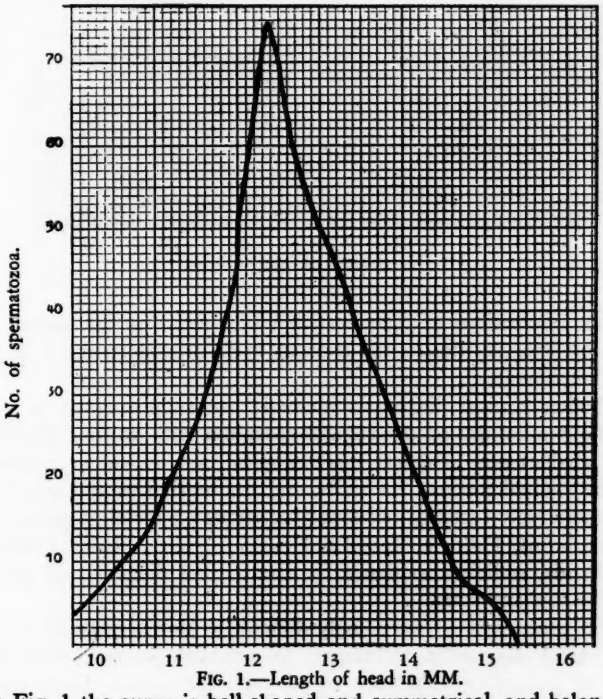

FIG. 1.—Length of head in MM.

In Fig. 1 the curve is bell-shaped and symmetrical, and belongs to a class called "curves of normal distribution"; the curve shown in Fig. 1a is much flatter and rather asymmetrical.

Relative frequency of teratological forms of the gametes may supply a further criterion for the assay of fertility in the sire.

Evaluation and interpretation of the spermiogram, as revealed by the microscopical examination of the semen, in combination with correlative data regarding the previous breeding record, yield evidence on the strength of which a timely successful treatment can be instituted, or decision taken to exclude the sire from the stud before much damage has been done.

Frequency of head-lengths in a sample of infertile semen.
(After Moench)

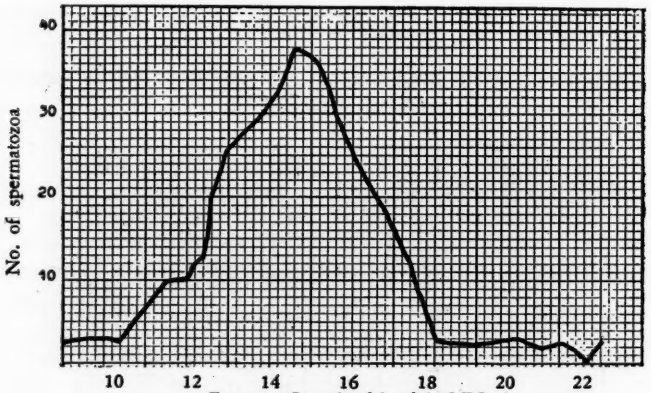

FIG. 1a.—Length of head in MM.

In the dam.

In the dam aberrations of reproductive health manifest themselves in the first instance by irregularities of the œstrous cycle or abnormalities in sexual behaviour (nymphomania).

The orthodox clinical diagnostic methods are supplemented in modern practice by the routine use of the vaginal speculum with various illuminating devices; this enables one to detect macroscopical, anatomical or pathological changes in the vaginal mucosa, its walls, and the uterine os and cervix.

The comparatively recently developed technique of rectal palpation of the uterus, uterine horns, Fallopian tubes and ovary supplies, almost infallibly in experienced hands, sufficient evidence for the correct diagnosis of abnormal condition in the cow and mare.

In general practice it is exceedingly difficult, if not impossible with contemporary clinical diagnostic technique, to establish correct diagnosis of sterility due to endocrine unbalance or to such nutritional disturbances as calcium, phosphorus and vitamin E deficiency. Direct assay of the functional integrity of the female gonad is impracticable. For this, the exact time of ovulation has to be ascertained and the microscopical examination of the ovum may be necessary; they cannot be carried out on the live dam.

Indirect alternative diagnostic methods have been recently developed for small laboratory animals, and in the case of woman in human medicine, and are being elaborated for use in large farm animals.

It is claimed that smears made from vaginal secretion reveal a cellular morphological picture characteristic for each stage of the œstrous cycle (see Figs. 2-2b). (Milovanov[25]).

VAGINAL SMEARS FROM A COW (SCHEMATIC)

FIG. 2.—Proestrum.

FIG. 2a.—Metoestrum.

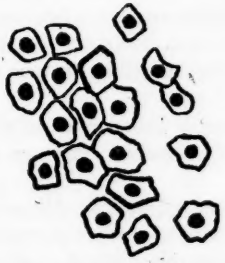

FIG. 2b.—During "heat." Oestrum.

In the cow before "heat" (2) the flat cells are smaller, oval in shape and have larger nuclei; during "heat" (2b) there is a great number of flat irregular cells with large nuclei and an almost complete absence of other cells; after "heat" (2a) there are many leucocytes, and irregular cells disappear. In addition, in the human female, the examination of a portion of endometrium (biopsy) is said by Lane-Roberts[20] to be of great assistance in deciding whether the specimen corresponds to the follicular or luteal phase of the uterus. Perhaps this latter method could be used with advantage in veterinary practice if its diagnostic value be proved by experiments.

Persistent *corpus luteum* inhibits ovulation, and it or ovarian cysts are usually found in dams showing an aberrant sexual cycle; it should, however, be regarded as a symptom and not the cause of sterility, and its presence indicates a state of endocrine unbalance.

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The laboratory methods of the early diagnosis of pregnancy are mainly based upon detection by chemical and bio-chemical tests of specific changes in the blood, urine and milk of pregnant individuals, or upon the presence in their excreta and secreta of endocrine principles which accelerate the advent of puberty in immature small laboratory animals.

The presence or absence in tissues and the use of such active endocrine compounds as œstradiol, œstrone, œstriol, equilin and equilenin are said to be of diagnostic value in cases of sterility. However, the various tests elaborated by modern investigators must all be carried out in a well-equipped laboratory, and their value in animal practice needs further proof.

IV. Treatment

Both in the sire and the dam functional sterility due to congenital impairment (free-martin, crytorchidism, inter-sexuality, inter-species hybrid, etc.), or to gross lesions of the gonads and adnexa is incurable if accompanied by destruction of spermatogenic and ovarian tissues or other *impedimenta* to the union of the gametes.

Reduction of scrotal hernia, frequent tapping in cases of hydrocele, surgical removal of the neoplasmata of the penis, prepuce, vulva, vagina, cervix, uterus, persistent *corpus luteum* or ovarian cysts may in some cases restore the fertile state. Such procedures are, however, sometimes costly, and one often finds in practice that owners are unwilling to take the risk except in the case of very valuable animals.

Much more frequently one is called upon to deal with cases of impaired fecundity due to multiple causes which may or may not yield to rational treatment.

The system of treatment inaugurated by Albrechtsen[2] and Nielson[28] has been attended with success where uterine symptoms dominate the clinical picture. It is doubtful whether this method is effective in cases of impaired fecundity due to nutritional deficiency or endocrine unbalance.

Artificial insemination which is not applied to any extent in breeding practice in this country *should be used early and before* other methods of treatment have already failed.

Artificial insemination obviates the excessive sexual exploitation of the sire; it affords considerable saving in stud and breeding fees; it prevents the spread of genital disease; and it yields clinical evidence of diagnostic value when an apparently normal dam fails to conceive after insemination with normal semen from a proven sire. Modern field technique of artificial insemination of cattle, sheep, horses and pigs has been sufficiently well developed in this country and abroad to warrant its general introduction; and a veterinarian is better qualified to carry it out in the field than members of other professions.

Centrifugation and buffering of the seminal fluid may be recommended

in those cases in which valuable sires suffer from olygospermia both as regards the concentration of the gametes per unit volume and the volume of the ejaculate itself.

The efficacy of many commercial androgenic and female gonadotropic preparations—for the successful application of which many exaggerated and unjustifiable claims are made—must be further tested both in the laboratory and the field. Until their beneficial specific action is indubitably established in conjunction with differential diagnostic methods, their indiscriminate use both on account of uncertainty of effect and cost must be discouraged. Bottomley and others[4] claim success in the treatment of sterility of bulls and cows with injections of human pregnancy urine extracts; as no controls were included in the tests it is questionable whether the restoration of fertility was due to the specific treatment or to the spontaneous recovery.

Carlson[6] writes that *"endocrine therapy is worthless without the application of principles and practices of veterinary gynæcology."* All kinds of investigators conduct researches which should by rights be pursued by the veterinary profession, and publish their findings which at times are severely criticised by experienced veterinary practitioners and clinicians. Young members of the veterinary profession will find themselves before long, after long and expensive training, crowded out from profitable fields of research and study if they do not assert vigorously their rights in this respect. Carlson further holds the view that nutritional disturbances are at the root of endocrine dysfunction.

Sterility due to prolonged vitamin E deficiency is incurable in the sire but can be successfully treated in the dam by administrations of vitamin E concentrate (Wheat Germ Oil). In the male, chronic vitamin E deficiency results in irreversible destruction of the germinal epithelium; in the dam an early abortion or resorption of the fœtus occurs. Where the cure of the sire is claimed to have been effected the success was probably due to the fact that dietary deficiency was of short duration, and part of the spermatogenic tissue in one or both testes remained intact. Frequent occurrence of early abortions of indeterminate origin, if combined with correlated evidence of dietary deficiency, may be successfully treated with vitamin E concentrate; in some cases a simple adjustment of feeding ration to include substances rich in vitamin E, such as bran, offals, etc., effects the cure. The success or failure of such treatment depends largely on the correctness of differential diagnosis.

V. Prophylaxis

High degree of in-breeding for the enhancement of performance and usually associated with partial or general hyperfunction is probably the true cause of impaired fecundity where the aberrant state cannot be logically traced to other known causes. This may hold true in the case of racing or heavy

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horses, high yielding dairy cattle, dual purpose fine wool and mutton strains of sheep, and early maturing bacon pigs.

Prolificacy is supposed to be a hereditary factor in the Mendelian sense. Impaired fecundity may, in some as yet unknown fashion, become a true heritable factor if fixed in association with single or multipule hyperfunction resulting from breeding for high performance.

On the other hand, it is quite possible that hyperfunction (such as peculiar constitutional development of racing and heavy horses, high-yielding cattle, dual purpose types of sheep, early maturing breeds of pigs) makes such a demand on the animal organism that the state of endocrine unbalance ensues and leads to impairment or repression of reproductive function. It is known that athletes, professional dancers, horsemen and sportsmen show greater degree of sexual rigidity and aberration of sexual behaviour and are less fertile than other individuals.

Sanders[35] and Pettit[30] established the fact that the average herd life of a high-yielding milch cow is between 3-4 years, and that it is higher in animals of low yield.

As longevity is also regarded as a heritable factor, this line of thought leads to the suggestion that prolongation of absolute or herd life of an animal in combination with a lower standard of performance may, without undue economic loss, prevent the occurrence of impaired fecundity.

Apart from these considerations on the purely genetical or endocrine plane, attention paid to the " fertility of mating " can be the means of prophylaxis in cases of supposed sterility. It is as yet not fully realised, either by breeders or veterinary practitioners, that the time and frequency of mating may be of decisive importance in affecting the number of pregnancies, and, thereby of offspring. In some animals œstrus is very short (ewe, goat, cow), in others it is fairly long (sow, mare, bitch, cat). The ovulation takes place either continuously (sow, bitch, cat) or at a certain well defined period of " heat " (ewe, goat, cow, mare). In range animals sires serve dams repeatedly throughout the period of " heat," thus ensuring that sufficient numbers of spermatozoa are present in the upper third of the oviduct when mature ova have been shed. Therefore in herds, flocks and studs, where hand-mating and service is the rule, a sufficient number of matings and inseminations, and as near as possible to the known time of ovulation, should be allowed throughout the period of " heat." By this means considerable number of breeding failures or the loss of stud fees could be prevented or obviated.

The routine practice prevalent in many studs or herds of vaginal douching with water, soap emulsion, mild disinfectant or normal saline before service cannot be too strongly deprecated. It brings about changes in the vaginal reaction which may have a spermicidal effect; at best, as the sperms move in normal vaginal reaction chemotactically, away from the acid medium of the

posterior portion of the vagina and towards the alkaline medium of the cervix, the douching with alkaline solution reduces by 50 per cent. the chances of impregnation; sperms disperse in all directions in an alkaline or neutral vaginal medium. Manual removal of the excessive vaginal mucus with a hand rinsed with normal saline is usually the only operation that should be allowed or required.

To guard against the possible loss, no sire should be allowed to enter the stud until the state of his reproductive health, as revealed by microscopical examination of the semen and of the spermiogram, has been found to be consistent with a high breeding performance.

In view of the seriousness of the annual loss due to sterility one may suggest that the schedule of notifiable animal diseases be revised to include some of the conditions associated with aberrant sexual function or performance. A state subsidy may be granted or a scheme of voluntary insurance be inaugurated for payment of compensation to the breeder for the destruction of infertile animals.

Conclusion

Most of the diseases of reproduction in farm animals are preventable or yield to a timely and rational treatment. Steele-Bodger[38] estimates that annual loss due to various diseases of livestock in this country is in the neighbourhood of £19,000,000; of this at least one half, as has been proved above, may be due to sterility and impaired fecundity. In this emergency we must aim at eliminating waste and reaching the highest pitch of efficiency in food production.

National health and efficiency will be gravely jeopardised if we keep on dissipating our capital—the finest livestock in the world—at such a rate, thereby increasing the costs of production and of primary health giving commodities (milk and meat) to the consumer.

The time is ripe for a concerted effort in tackling this urgent problem by the state, farming community and veterinary profession.

There are sufficient guarantees that field, laboratory and research work will henceforward be pursued unceasingly until the final goal—the complete control and eradication of sterility is attained.

Summary

1. It is estimated that the annual loss due to sterility and associated conditions amounts to about one-half of that caused by "disease."
2. A short survey of salient facts relevant to modern views of the causes, diagnosis, treatment and prophylaxis of sterility and impaired fecundity is given.
3. Universal application of artificial insemination as a breeding method of choice is advocated.
4. Inclusion of some conditions due to sterility into the schedule of

notifiable animal diseases, and state subsidy or voluntary scheme of insurance, for compensating the breeder for the loss incurred, are suggested.

5. Concerted effort by the state, farming community and veterinary profession, to deal effectively with the control and eradication of sterility and impaired fecundity is urged.

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Clinical Articles

TUBERCULOSIS OF THE BRAIN AND MENINGES IN BOVINES

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It is usually accepted that tuberculosis of the brain and meninges occurs most frequently as a result of blood stream infection from some focus in another part of the body, and that the organisms become lodged in some of the small branches of the cerebral or meningeal vessels. There the organisms give rise to the formation of tubercles from which extensions occur through the perivascular spaces. It has even been stated that tuberculous meningitis is always secondary in tubercles which form in connection with the brain

substance, the tubercle bacilli escaping thence along the perivascular spaces into the subarachnoid space and so involving the meninges. This view has followed on the work of Rich. Despite this view there are many cases in which the lesions in the brain substance are not discovered and it is not improbable that in bovines at least tuberculous meningitis may develop independently of cerebral lesions. In a case recorded by us in THE VETERINARY JOURNAL (1940), Vol. 96, p. 337, the tuberculosis of the pia mater extended throughout the whole length of the central nervous system although no tubercles could be determined in its substance by making thin transverse slices through the brain or cord.

There are, however, occasions in which the cerebral lesions are extensive while the lepto meninges are only slightly involved and these lesions in the lepto pia mater are secondary to the tubercles in the brain.

Moreover, there appears to be considerable variation in the rapidity of development and in the nature of the symptoms which may be seen, according to the part which is involved. This may be illustrated by reference to two cases which have recently been brought to our notice.

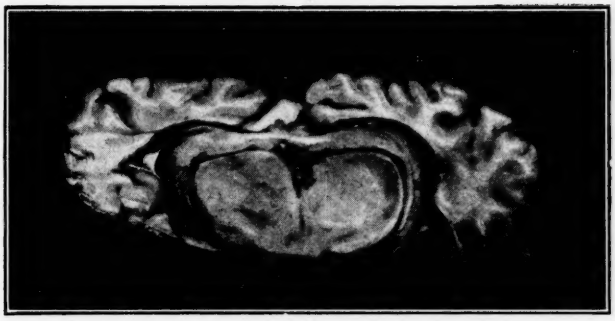
Case No. 1

This was a 15-months-old red and white Shorthorn heifer which had been showing symptoms for some weeks. Although the nervous symptoms were very marked, the condition of the animal was not poor and it fed well. The heifer was very nervous or hyperæsthetic and difficult to approach and handle. It became very excited and struggled violently on manipulation. There were slight tremors or spastic contractions over the head and neck. The head was poked out and turned to the right side. When left alone it stood leaning against the wall of the box with its left side and its head pressed against the wall in front.

It was tested intradermally with tuberculin and gave a definite reaction.

Post-mortem.—Tuberculous caseous lesions, the size of a pea or less were noted in the left submaxillary, right parotid, bronchial, mediastinal, hepatic and mesenteric glands. The lungs presented some areas of caseous bronchopneumonia chiefly at the base of the lungs and isolated tubercles elsewhere in the lung substance. There was some compensatory emphysema. A few red patches of granulation-like tissue were noted along the lower parts of some of the intercostal spaces. The liver contained a few small grey tubercles. On opening the cranium and cutting through the dura mater a considerable amount of fluid welled out from the surface of the brain, the convolutions of the cerebrum were compressed and the lateral ventricles were distended with the same kind of fluid. The fluid was opalescent and colourless. It formed a fibrinous clot and contained many lymphocytes, but no tubercle bacilli were found in it.

FIG. 1.



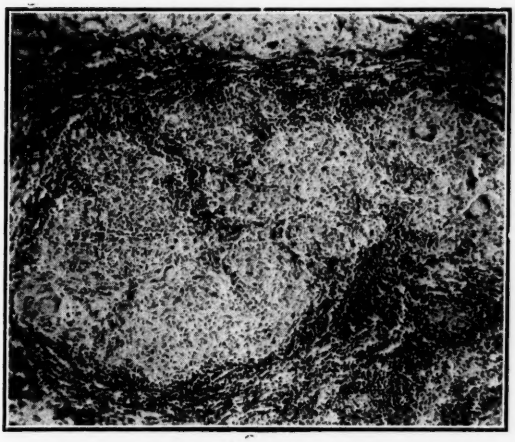


FIG. 2.

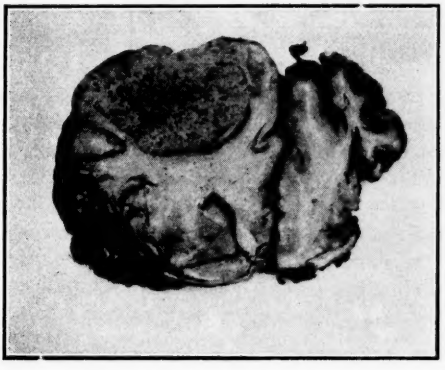


FIG. 3.

FIG. 4.

FIG. 1.—Transverse section through the cerebrum, the hippocampi and thalami of Case 1, viewed from the front, showing irregular changes in the right thalamus. × ⅔.

FIG. 2.—Photomicrograph of a section through affected part of thalamus of Case 1, showing non-caseating tubercles surrounded by a thick fibrous layer. × 100.

FIG. 3.—Transverse section through cerebrum of Case 2, showing large caseous tuberculous mass in left cerebral hemisphere and atrophy by pressure of right hemisphere, viewed from behind. × ½.

FIG. 4.—Photomicrograph showing cellular infiltration of a vessel in cerebral cortex outside the tuberculoma of Case 2, and large numbers of histiocytes and lymphocytes in the surrounding nervous tissue. × 100.

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The pia mater at the base of the brain over the interpeduncular space, the fissure of Sylvius, the under aspect and side of Pons and medulla including the choroid plexus of the fourth ventricle was thickened, pink in colour and dotted with tiny grey tubercles. There was a small patch of a similar nature on the first part of the pia mater of the cervical cord.

On slicing the brain into thin parallel slices by transverse vertical incisions a large yellow firm area, not well defined, was found to involve a large portion of the right thalamus (see Fig. 1). The lateral ventricles and the iter of Sylvius were very large.

Histology.—In the cervical cord, where tubercles were apparent to the naked eye, a small patch of the pia mater was studded with tubercles rich in giant cells. Tubercle bacilli were scarce.

The medulla was clothed on its under and lateral aspect with a pia mater infiltrated with lymphocytes and epithelioid cells, and was dotted with some distinct tubercles. The adventitia of the vessel walls in places was invaded by the component cells of the tubercles and the choroid plexus of the fourth ventricle was also involved. The latter changes may have accounted for the distension of the ventricles with fluid by interfering with its passage from the ventricles into the subarachnoid space.

In two of the larger arteries there was a considerable amount of fibrous thickening of the tunica intima. The only alteration observed in the substance of the medulla was "cuffing" of several of the pial vessels which were surrounded with several layers of lymphocytes and some histiocytes.

The pia mater under the cerebral peduncles presented similar lesions to those noted under the medulla. The main change involved a large proportion of the right thalamus as far as the lateral edge. The affected area was dotted over with typical miliary tubercles rich in giant cells and tubercle bacilli and separated by strands of fibrous tissue. In a few of the tubercles the centres had become caseous and calcified, but in the bulk of the lesion these changes were absent. In the neighbouring areas many of the nerve fibres had undergone degeneration and a number of the pial vessels were surrounded by several layers of lymphocytes and a few endothelioid cells.

It was evident in this case from the stage of development of the lesions that the thalamus in the brain was first affected and the meningitis was secondary to the changes in the thalamus. Moreover, the brain lesions arose from the transport of tubercle bacilli in the blood stream from other lesions in the body. The affection of the thalamus as the main sensory relay station to the cerebral cortex no doubt accounted for the nervous phenomena shown by the animal during life.

Case No. 2

This case was one in which the brain had been removed by Mr. J. Holroyd, F.R.C.V.S., and forwarded to us as an interesting specimen. It came from a 2½-year-old heifer, newly calved, which had been purchased in a local market

a week prior to the onset of symptoms. It was apparently healthy until one morning when it started, as the owner described it, to go "mad," and died in seven hours. In addition to the brain lesions, post-mortem examination revealed the presence of tuberculosis of the lungs, pleura and mediastinal lymphatic glands.

The brain as received presented very little change in the meninges save over the occipital aspect of the left cerebral hemisphere where the pia mater was thickened and slightly reddened.

On making parallel vertical and transverse incisions through the brain, a large tuberculoma (Fig. 3) was found to involve the left cerebral hemisphere where the pia meter was thickened. This mass was yellow and caseous, ovoid in shape, dotted with congested vessels and fairly well defined, about 2 in. wide x 1¼ in. in depth and 1½ in. long. It extended to the surface of the cortex. The mass was very firm, had caused some increase in the size of that part of the hemisphere and displaced the corresponding part of the right cerebral hemisphere and adjacent structures. This was the only lesion noted in the structure of the brain.

In sections prepared from the part of cerebral hemisphere involved, the surface pia mater was infiltrated more or less diffusely with lymphocytes and some histiocytes and with sero-fibrinous exudate. In the neighbouring structure outside the tuberculous zone the walls of the pial vessels showed very marked "cuffing" and lymphocytes and a few histiocytes were scattered irregularly through the nerve tissue. Moreover, at some points small spaces were noted which had no doubt been saturated with sero-fibrinous exudate.

On the outer border of the tuberculoma there was a thick layer of lymphocytes and this was also noted in connection with the outer borders of many caseous centres in the lesion. Under the layer of lymphocytes there was a varying amount of epithelioid tissue. In this latter material giant cells were not uncommon, but not nearly so frequent as in two previous cases. A large proportion of the mass had undergone caseation and there were also in it centres of calcification. Tubercle bacilli were difficult to find. In this case one takes it that the transport of tubercle bacilli was blood borne and carried in one or other of the cerebral arteries in the terminals of which they had been arrested. These bacilli had probably come from the thoracic lesions.

The symptoms shown were, no doubt, set up by the changes in the cerebral hemisphere.

The remarkable feature of the case was the rapid development and course of the symptoms. The flare-up of these symptoms suggested that the lesions had advanced rapidly at least in the later stages, and the extensive necrosis and caseation without any attempt at fibrosis limitation tended to support this view.

The other point of interest in the case was the small number of tubercle bacilli which were identified in the cerebral lesions.

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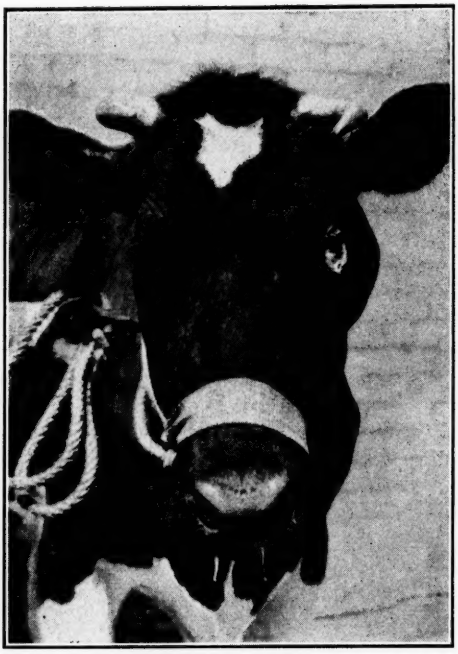

FIG. 1.—Tuberculosis of the left lower eyelid and enlarged parotid lymph gland in a three-year-old heifer.

BOVINE TUBERCULOSIS INVOLVING THE EYELID

By J. F. CRAIG and G. O. DAVIES

Department of Veterinary Pathology, University of Liverpool.

It is by no means rare to meet with tuberculous lesions involving the eyeball. There they develop in connection with the choroid or iris and may extend thence to the other structures of the eyeball forming a red caseous granulating mass from which a yellow discharge issues and flows over the face. In the discharge tubercle bacilli can often be readily recognised.

The conjunctiva and the eyelids apart from the eyeball are less commonly affected. In April, 1940, we had the opportunity, through the courtesy of Mr. Kendrick, M.R.C.V.S., Tarvin, of examining and observing a case of this kind.

The animal was a three-year-old British Friesian heifer which had already calved her first calf, but had not subsequently been served. She was in fair condition but giving only about one gallon of milk per day.

The main symptoms shown involved the left lower eyelid and the neighbouring parotid lymphatic gland (see Fig. 1). The eyelid presented a raw red swelling along the conjunctival surface and the free edge and there was a yellow opaque discharge which adhered to the eyelids and flowed over on to the face.

The parotid lymph gland was greatly swollen up to the size of the palm of the hand and very tense.

Films of the discharge were examined microscopically for tubercle bacilli with negative results. The parotid gland was incised but was found to contain no pus. Some pieces of the tissues were taken from the cut surface of the gland and when sectioned tubercle bacilli were demonstrated in small caseous areas in the tissue.

The heifer was tested with tuberculin intradermally at the side of the neck, and at the caudal fold. In the former test the skin measurements were 6 mm., 11 mm. and 12 mm. at the time of the first injection, 48th and 72nd hour respectively. The swelling was diffuse and tense. The injected caudal fold showed a diffuse swelling at the 72nd hour which was three times that of the fold of the opposite side.

The animal was kept under observation for two months in the Department, but she declined in condition, although the local swelling of the eyelid decreased.

She was subsequently destroyed.

On *post-mortem examination* tuberculous caseous lesions were found in the left parotid, the submaxillary, pharyngeal, bronchial, mediastinal and

hepatic glands. In addition to the firmer yellow caseous areas in the parotid, submaxillary and pharyngeal glands, there were large pockets of yellow-green tough pus which contained a few tubercle bacilli, but no other organisms, and broken down cells. The swelling of the left lower eyelid was small and firm and on section presented the typical histology of tubercles undergoing necrosis in the centre and surrounded by fibrous tissue.

Both lungs presented numerous large grey-green solid areas with little caseous spots through them and some vesicular emphysema, and the pleura was covered with red flat grapes. The peritoneum was covered in its anterior portion with red granulation-like tissue, involving the anterior part of the rumen, the spleen and liver. The liver contained a few caseous tubercles about the size of walnuts and the cortex of the kidneys was dotted with small grey tubercles about the size of a pinhead. The udder presented lesions of lobular tuberculosis over the lower portion of the left hind quarter which was slightly indurated. Previous microscopical examination of the milk failed to reveal any evidence of the infection.

The affection of the eyelid was probably secondary to the lesions elsewhere in the body and it is possible that it may have been contracted by some discharge such as the fæces which was inoculated into an abrasion on the free border of the eyelid. The neighbouring lymph gland presented a greater involvement and enlargement than any of the other lymph glands and this rather supported the view that the infection of the eyelid had come directly from the surface.

A SUGGESTED TUBERCULIN TESTING SYRINGE

By L. E. A. ROWSON, M.R.C.V.S.
Cannock, Staffs.

May I put forward, purely as a suggestion and inviting criticism, the following modification of the usual type of tuberculin testing syringe.

It is usual for most veterinarians to use the dental type of syringe with interchangeable needles, the dose being read either by graduations on the glass or by means of a runner which travels over similar graduations on the shaft of the plunger. The latter is the more exact, but it is often difficult to adjust the runner to the required position quickly and accurately.

By altering the type of the plunger shaft and replacing the runner by a sliding metal stop, these difficulties would be overcome and dosage would be exact and self-measuring.

The usual plunger stroke in a 1 c.c. syringe is approximately 27 m.m. and the internal diameter of the barrel approximately 7 m.m.

The round plunger shaft is replaced by one with a flat surface on each side, 3 m.m. across, its thickness being 2 m.m., and from the edges of which teeth project alternately, as shown in Fig 1.

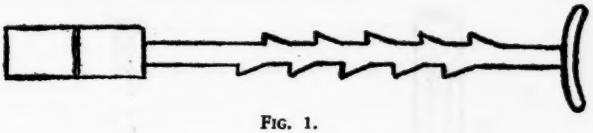

FIG. 1.

Each tooth would project 1 to 1.5 m.m. and the length of each tooth would be 2.5 m.m. as shown in Fig. 2.

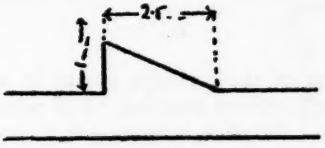

FIG. 2.

The teeth alternate so that the shoulder of one is exactly opposite to the point of union of the hindmost part of the preceding tooth to the shaft of the plunger. (Fig. 3.)

FIG. 3.

The collar of the syringe is slotted to allow a sliding plate to be moved freely backwards and forwards through it. (Fig. 4).

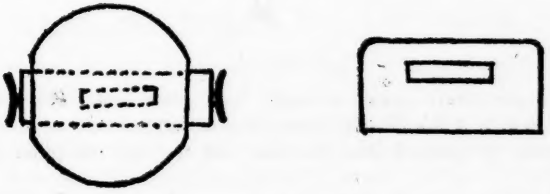

FIG. 4.

The plate fitting into the slot has a rectangular hole cut through the centre while at each end it is fitted with flat press buttons, one of which is screwed on and can be removed. (Fig. 5.)

The edges of this hole in the plate at the shorter side of the rectangle are bevelled with a pointed edge uppermost and the angle of the bevelling corresponding to the shape of the tooth from the shoulder to the plunger

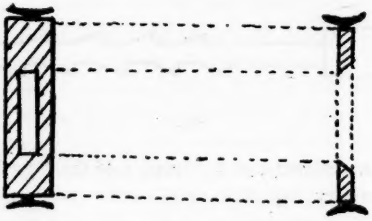

FIG. 5.

shaft. The total length of the rectangle would be sufficient to allow shaft and teeth to pass through without touching, i.e., 7 m.m.

The whole length of the plate is about 4 m.m. greater than the width of the collar while the sides of the collar through which the plate passes are slightly flattened.

The upper surface of the collar also has a hole similar in shape to that of the plate but slightly larger.

The plate and collar are fitted together as in Fig. 6, the plate being freely movable in the collar slot but prevented from being pushed out by the thumbscrews S.

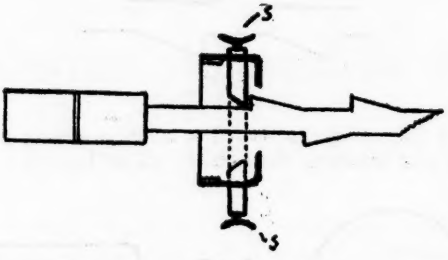

FIG. 6.

The plunger shaft passes through both plate and collar slots—against the sides of which it fits closely, preventing rotation.

The collar is screwed into position and the syringe filled in the usual way.

The plate is now pushed over by pressing the button B (Fig. 7) and the edge of the rectangular hole comes into contact with the plunger shaft. The plunger is then depressed until the first tooth strikes the plate. The syringe is now ready for use, the first tooth representing the beginning of the graduations.

The plate is now pushed over by pressing the opposite button S (Fig. 7) until it strikes the other side of the shaft exactly opposite the shoulder of the first tooth. Depression of the plunger is now possible until the next tooth strikes the plate representing a dosage of 0.1 c.c., the plunger having travelled 2.7 m.m.

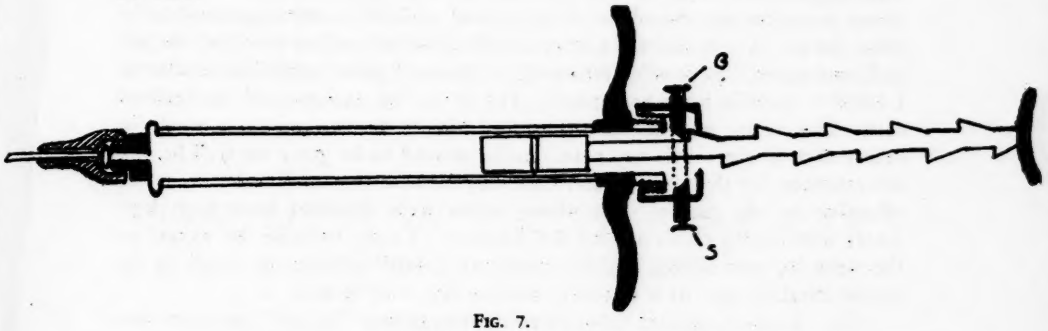

FIG. 7.

The process is then repeated all the way up the shaft. All that is necessary between each injection is to push the plate across and depression of the plunger will give an exact dose which will not vary from animal to animal.

May I add that these suggestions are purely theoretical and such a syringe would be open to criticism, for example :—

(1) Wear on the teeth and plate.
(2) Lateral movement of the shaft causing the teeth to miss.
(3) Slipping of the plate out of position.

Wear should not be great and in a well-fitting plunger lateral movement of the shaft is very small, while slipping of the plate could be prevented by the use of a little vaseline.

IMMOBILISATION OF WOUNDS

By A. A. FORSYTH, M.R.C.V.S., D.V.S.M.

Case 1.—A black spaniel dog, five years old, the chief companion of an invalid, was run over by a motor lorry while at exercise. The left tibia had a simple fracture about an inch above the hock. The right hind leg was contused from the hip to the toes. The skin and ligaments were missing from the outside of the hock and the bones and joint exposed for an area about an inch wide and two inches long. Grit was ground into the surrounding tissues and tiny chips of bone and grit were mixed in between the small bones of the hock joint. I advised destruction as I did not think that treatment would be

of much avail. The owner begged me to give him a trial, which I did with much reluctance. He was chloroformed and the long hair clipped from both legs. The fractured tibia was reduced and set in cellona. The right leg was washed with soap and water and dried with spirit. The hair around the main wound was clipped close with scissors but not shaved. A tourniquet was applied above the stifle and the edges of the wound excised to what appeared to be clean tissue. The bones were scraped with a scalpel and as much of the grit and bone splinter as possible removed. A piece of gauze soaked in acriflavine 1-1,000 in paraffin liq. was applied. The whole leg was encased in a cellona cast. The owner was instructed to send him to the surgery in a week, or before then if there was any pain. As he seemed to be going on well he was not returned for three weeks and then only because the smell had become too offensive for the house. The plaster cases were removed from both legs. There was a good callus around the fracture. To my surprise the wound on the right leg was almost healed; there was a small granulating patch in the centre about the size of a sixpence, and the dog walked well.

Case 2.—A " Lurcher " dog of unknown age was " spiked " on some iron railings while poaching. The right fore leg had a lacerated wound about two and a half inches long. It was midway between the knee and elbow and extended into the flexor muscles at the back of the leg, exposing the ulna. The spike had entered in an upward direction and the dog had hung on the fence for a few minutes until he could be lifted off. The interior of the wound was at least an inch longer than the lips and the sides of the cavity were extremely dirty from mud and rust. A tourniquet was applied above the elbow and the wound laid open. The whole wound was excised, leaving an elliptical wound about three and a half inches long; the exposed ulna was scraped. Deep sutures of catgut were inserted to pull the sides together. A piece of sterile gauze was laid over the wound, and the whole leg, including both elbow joint and toes, was encased in cellona. This was left in position for ten days. On removal, the wound was completely healed, the gauze was dry and there was no smell.

Case 3.—A Red Setter bitch, three years old, had been run over by a motor lorry which skidded on the snow. The second digit of the right hind foot was badly crushed and the last two phalangeal joints exposed. The wound was frostbitten and was of a dirty purple colour.

The nerves were blocked with chlorocain and the toe, including the pad, amputated at the metatarso-phalangeal joint. The wound was sutured with catgut and a piece of sterile gauze laid over it. A cellona cast, which included the hock, was left in position for twelve days by which time the wound was healed.

The results in small animals of this method of wound treatment are very encouraging. In large animals immobilisation is extremely difficult and in many cases impossible.

The excision of damaged tissue is not a new treatment and has been carried out in a greater or lesser degree in my practice for as long as I can remember.

When toes are included in a plaster case it is often difficult to keep the plaster dry and prevent wear. A very useful galosh can be made by slipping a length of cycle inner tube over the foot and tying with a string at the toe or alternatively, folding it backwards at the toe and tying higher up the leg. The latter method gives three layers of rubber under the sole where most wear takes place.

RAW LIVER IN THE TREATMENT OF ANÆMIA IN HORSES

By A. A. FORSYTH, M.R.C.V.S., D.V.S.M.

THE anæmia which follows heavy infestations of red worms in young horses is extremely difficult to treat.

Four three-year-old ponies were heavily infested with red worms. They were all extremely weak, with profuse diarrhœa; the mucous membranes were almost white. They were dosed with Ol. Chenopodii, followed by daily doses of Ferri Sulph., Cupri Sulph. and Sodi Chlor. Two of them became rapidly weaker until they could only rise with assistance and refused all food. It was left with me as to whether they should all be shot or treated further. I decided to give them a week's trial with raw sheep's liver. Two ounces of fresh sheep's liver were minced and mixed with half a pint of thin flour gruel and given as a draught once daily to each of the two worst. The two stronger ones were kept on the old treatment and left as controls. After the second dose they licked the bottle-neck and the few spilled drops from the floor, so it was decided to mix one ounce of minced liver with a small feed of bran oats and chopped hay. This they ate, but refused to take any food without the liver. Three ounces were then mixed with a whole day's food for the two and given in three feeds, all of which they ate. At the end of the week the diarrhœa had ceased, they could rise without help, and the mucous membranes were almost of normal pink colour. The two controls were becoming weaker and refusing food. They were offered a food containing liver but refused it. They were drenched with two ounces of liver in gruel for two days, after which they ate all food offered containing liver but refused everything without it. The recovery was uneventful and they have worked in the mines ever since they became of age. One of the two worst was shown at the Royal Show at Windsor.

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Since this series of cases I have used raw sheep's liver as an almost routine treatment of anæmia in colts with good results. The convalescent period, usually so long, is considerably reduced. I have yet to see the horse which refuses to eat it in his food after he has been drenched and acquired the taste.

EARLY PREGNANCY

By R. C. IRVING. F.R.C.V.S.
Shenley, Herts.

EVERY now and again one hears of mares which have given birth to a foal quite early in life. The following record is, in my opinion, unique. I can vouch for the correctness of the dates for the mare in question is owned by me and kept on my farm.

The mare is a blue roan by the thoroughbred stallion "Eat at Ease" and out of a pure-bred New Forest pony.

She was foaled on May 4, 1938. On May 30, 1940, she gave birth to a brown colt foal. It is by a four-year-old New Forest stallion.

Mare and foal are doing well and the foal is a good specimen of its type.

Abstracts of Current Literature

Permanent Distemper Immunisation by Vaccine Alone. By LEON. F. WHITNEY, Vet. Med. (1940), *XXXV*, 408.

The author reviews some of the experiences of veterinary surgeons in America who have different opinions concerning the value of dried virus in the vaccine-virus method of immunising dogs against distemper. Samples of dried virus were examined and many failed to infect susceptible puppies. (It would appear that some at least of the dried virus issued in America is used long after it is issued in contra-distinction to the procedure in this country where a very limited time limit between issue and use is advised.) Vaccine made from the spleen of a dog killed 9 days after artificial infection and used immediately after preparation, protected a series of 31 puppies. In the same kennels were 16 unvaccinated puppies. Exposure to natural infection caused the loss of 14 out of the 16 unvaccinated puppies, while of the 31 vaccinated animals 27 withstood the infection and four contracted the disease but recovered. The author concludes that it is possible to immunise a dog

solidly by the use of high potency fresh vaccine alone. He thinks, however, that the injection of virus should be regarded as an insurance, in the event that low potency vaccine is used which does not completely immunise but which gives some degree of protection. He also thinks that it is advisable to grade the dose of vaccine to the size of the dog, rather than to administer a standard dose to dogs of all sizes.

The Effect of Vaccination of Guinea-pigs with the Vole Acid-fast Bacillus on Subsequent Tuberculous Infection. By A. Q. WELLS and W. S. BROOKE. *Brit. Jl. Exp. Path.* (1940), *XXI*, 104.

In this article is reported the results of experiments in which it was shown that the vaccination of guinea-pigs with sub-lethal doses of the vole acid-fast bacillus conferred a considerable degree of immunity against infection with virulent mammalian tubercle bacilli. Three experiments are described.

In the first, six guinea-pigs were used—three vaccinated and three controls. Bovine tubercle bacilli were injected subcutaneously 9 months later. There was a marked difference in the degree of infection in the two groups when they were killed in 6 months—no macroscopic lesions were found in the vaccinated group except at the site of injection. In the second experiment, 15 guinea-pigs were used—divided into 3 groups of 5. One group received 1 mg. of the vole culture; the second group 0.1 mg.; the third group was not vaccinated. Three months later all the animals received an infecting dose of human tubercle bacilli. The results indicated that 1 mg. of culture of vole acid-fast organism afforded a high degree of protection, though 0.1 mg. also afforded some protection. The third experiment comprised 47 guinea-pigs and was designed to compare the degree of protection conferred by the vole acid-fast bacillus and by B.C.G., against infection with human and bovine tubercle bacilli. Tests with tuberculin were also carried out. There was evidence of a higher degree of protection from the vole acid-fast bacilli than from B.C.G. though the animals injected with B.C.G. did not show such advanced disease as did the unvaccinated control group.

Inoculation and Immunity Experiments on Calves with the Vole Strain of Acid-fast Bacillus. By A. STANLEY GRIFFITH *and* T. DALLING. *J. Hyg.* (1940), *XL*, 673.

Following on the isolation by Wells of an acid-fast organism from the vole and the carrying out of some preliminary experiments, the above authors undertook some work on calves. They showed that the inoculation of young calves with cultures of the organism set up "a tuberculous reaction, chronic in nature, which tends to disappear without leaving many traces." Caseation in the true sense of the term does not occur but there is a "scanty necrosis." The organism was recovered from the tissues of calves 89 days after inoculation though the authors state that this is not the extreme limit of survival.

Immunity experiments were also carried out on calves. The cultures were

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injected subcutaneously and intravenously and in some cases one and, in others, two injections were given. The test for immunity consisted in feeding an infective dose of virulent bovine tubercle bacilli, at an interval of 208 to 223 days after the cultures of the vole strain were injected. Nine vaccinated calves and two controls were so fed. Both the controls became typically infected. Of the vaccinated calves, five had trivial tuberculous lesions in the glands adjoining the alimentary tract and four showed no macroscopic lesions in any gland or tissue. In some of the infected glands the numbers of living bovine tubercle bacilli were very sparse. The injection into guinea-pigs of emulsion of some of the glands which had shown no macroscopic lesions was followed by the development of tuberculosis.

Two injections of the vole strain did not produce any greater degree of immunity than did one injection. Subcutaneous injections were followed by no better results than intravenous injections. Subcutaneous injections give rise to large local lesions which break down into a collection of sterile purulent material.

Tests with mamalian tuberculin gave very pronounced reactions within 13 to 28 days after the injection of the vole strain.

The authors conclude that "the results obtained in calves with the vole strain of acid-fast bacillus was unexpectedly good and better than those which followed the use of B.C.G. as a vacine."

Musca Domestica a Vector of Bovine Mastitis (Preliminary Report). By D. A. SANDERS. *Jl. Amer. Vet. Med. Ass.* (1940), *XCVII*, 120.

The author carried out transmission experiments. Cows known to be free from infection were kept in a special screened isolation building where mastitis infection had not been introduced. Flies captured on infected premises were kept in a specially devised screen cage which facilitated the handling and transfer of the flies. Milk taken from diseased quarters and shown to be infected was placed in shallow containers in the cages containing the flies. The flies were allowed to feed on samples for 3 to 7 days and then were given no more food for a short time. By a specially designed piece of apparatus the flies were brought into contact with the tip of the cow's teat, from which small droplets of lactic secretion had been expressed. The flies fed readily on the secretion. "After consuming the milk droplets, the flies often were seen to insert the proboscis into the orifice with mop-like action, seeking further secretion. While the fly was crawling over the tip of the teat, the feet often were placed deep in the fossa, which is a very pronounced anatomical structure in some lactating cows." Another type of transmission experiment consisted in releasing several hundred flies inside a screened enclosure. Milk from diseased udders, incubated overnight, was placed before the flies. Lactating cows, free from mastitis, were introduced into the enclosure. The author states "by these transmission techniques mastitis

develops in each of the several experimental animals. Results of these tests show conclusively that *M. domestica* is a natural vector of bovine mastitis. Infections were established readily in udders where the lactation secretion was allowed to remain in the quarters, as occurs naturally when cows are 'dried off' prior to calving." His conclusions are: "From these observations it is concluded that the common housefly, *Musca domestica*, serves as a natural vector of bovine mastitis, and that the incrimination of this insect as a vector furnishes additional information necessary for the successful control or eradication of mastitis."

Uterine Tuberculosis in the Cow as the Cause of Tuberculosis in the Foetus. By K. A. HERMANSSON. *Skand. Veter.-Tidskt.* (1940), *XXX*, 627. (Author's Summary in English.)

In tuberculosis in the foetus of cattle, the mother has always been found to suffer from uterine tuberculosis. The mother's uterine tuberculosis, consequently, is the source of the tuberculosis in the foetus. The infectious material is conveyed from the uterus to the foetus by means of the foetal blood. The uterine tuberculosis does not always give rise to *visible* tuberculosis alterations in the foetus. Frequently (though not usually) the bovine foetus becomes infected when enclosed in the tuberculous uterus. In tuberculosis of the foetus, the lymphatic glands of the liver are always infected. Compared with this, tuberculosis in the other organs is comparatively rare. This circumstance is evidence that the greater part of the umbilical blood of the foetus first passes through the capillary network of the foetal liver before being conveyed onwards to the foetal heart. Evidently it is only a small portion of the bovine foetal umbilical blood which passes through the *ductus venosus arantii* direct to the foetal heart without first having passed through the capillary network of the liver.

On the Study of Micotic Colic in Horses. By D. SOKOLOV. *Scientific Proceedings of the Kiev Vet. Inst.* (1940), *2*, 132.

Laboratory examinations showed that flatulent colic was caused by *Rhizopus nigricans*, found on the dry bread on which the horses were fed. It was also shown that spasmodic colic occurred in horses fed on meal contaminated with a large number of spores of *Rhizopus nigricans* and *Sporotrichum Beurmani* with pathogenic properties demonstrated in an experiment in mice. In both cases the animals were cured when the causes were eliminated.

Zepharin in the Treatment of Foot-rot in Cattle. By J. W. SCALES, *Vet. Med.* (1940), *XXXV*, 335.

"Zepharin is a trade name for a mixture of high molecular alkyl-benzyl-ammonium-chlorides derived from the fatty acids of coconut oil. It is an efficient antiseptic of high germicidal and bacteriostatic potency, stainless, of

pleasant odour and, in proper dilutions, non-poisonous and non-irritating to tissues." The author has used this substance in the treatment of foot-rot in cattle. He cleanses the foot thoroughly by scrubbing with a stiff brush and water. All diseased tissue is removed, leaving a clean open wound. The preparation is then applied so that it reaches all the diseased parts. Eight cases were treated in the early stages and all recovered. In an advanced case it was necessary to pack the affected parts with zepharin. The author concludes " Zepharin has proved effective in the treatment of foot-rot in cattle, most cases recovering after only one application. It has proved far superior to the remedies previously used for this condition. It merits a trial in other necrophorus infections."

A Preliminary Report on an Infectious Encephalomyelitis of Cattle. By S. H. McNutt, *Vet. Med.* (1940), *XXXV*, 228.

A disease among young cattle—primarily an infectious encephalitis and meningitis—is described. It closely resembles Listerella infection, but all attempts to isolate that organism have failed. The disease was seen on four farms. The main symptoms were inactivity and a high temperature. Lesions of encephalitis and fibrinous peritonitis were common. Calves and heifers were affected. Deaths were common. Rabbits and guinea-pigs were easily infected by the intracranial and intraperitoneal injection of brain, liver, spleen and sero-fibrinous exudates. Blood did not prove infective. The causative agent seems to be easily killed. Calves injected subcutaneously with infective material show symptoms after an interval of 7 to 27 days. Symptoms are high temperature for a few hours, remaining high until soon before death or until recovery begins. Appetite remains good; gradually it fails and there is loss of condition. The major nervous symptom is cerebral depression. The course of the disease is 5 days to 2 weeks. About 60 per cent. of affected animals die. The lesions of the brain, cord, liver, and kidney are almost identical with those seen in malignant catarrhal fever and in listerellosis. The author says in conclusion that " it may be said that while it now appears that the encephalitis herein described is a new disease of young cattle, a final decision must await a more thorough study and a close comparison of it with all known forms." Further work is in progress.

Ropy Milk, Its Cause and Prevention. By C. K. Mader. *Can. Jl. Comp. Med*, (1940), *4*, 203.

Ropy milk must not be confused with the stringy condition of milk resulting from mastitis. The former comes from a healthy udder and is normal when drawn, the ropiness appearing in about 12 hours. It is characterised by the presence of silk-like threads, from a few inches to a few feet in length, and a thicker condition of the milk than normal. Different capsulated

micro-organisms have been described as the cause in different parts of the world. They have been isolated from such sites as stable bedding, milk stools, pails, gutters, stable air, cooling water, cooling tanks, strainers, fodder, barnyards, pastures, weigh vats, pipe lines, milk cans, etc. Contamination of milk takes place during milking or its subsequent handling.

The author describes a simple method of detection. Samples of raw milk should be obtained "in sterile half-pint bottles, filling to about ½ inch from the top, capping with a sterile cap and incubating the samples at 60 degrees to 65 degrees F. from 12 to 48 hours: at the end of 12 hours, 24 hours and 48 hours a platinum wire or needle is flamed and the sample is tested by dipping into the surface of the cream the point of the needle in spots along the circumference and then gently raising it after each dip to see if there is evidence of rope, which is seen by the cream stretching for half an inch or more. The natural viscosity of the cream will cause it to adhere as the needle is raised, but the column between the surface and the needle will break before it can be drawn out into thin threads which are characteristic of rope. Care should be exercised to use a sterile needle or platinum wire for each individual sample to be so examined." A method is also described whereby the causal organisms are cultivated and examined. To prevent the condition "strict sanitary measures must be adopted and a thorough sterilisation of all equipment with either live steam or chlorine" must be carried out. Returned bottles of milk should not be repasteurised or put back into the plant.

OBITUARY

SIR JOHN McFADYEAN, LL.D.

It is with deep sorrow and sincere regret that we announce the death of Sir John McFadyean. He died at Hindhead, Surrey, on Saturday, February 1, in his 88th year. Throughout his long life Sir John worked for the welfare and advancement of his profession. It may be said with truth that the high status which the profession has now attained is in no small measure the direct result of his endeavour.

His was a life well spent and full of years and honour. It is good to know that there was only a short period of bodily illness and that his great mental faculties were unimpaired to the end. He died peacefully. In a subsequent issue we intend to pay a tribute to the life and work of this great veterinarian.

XUM

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